The Modular Open Systems Approach:
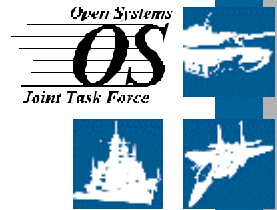## A Prescription for Geriatric Weapon Systems

Tampa, FL
23 October 2002

Glen T. Logan, Lt Col, USAF
OUSD(AT&L)/OSJTF
(703) 602-0851 x112
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Charles R. Hurst
Information Spectrum, Inc.
(937) 256-9933
hurscr@ispec.com

Agenda

- The Aging Weapon Systems Problem
  - Electronics Marketplace Status
- MOSA: Enabler for Defense Transformation
- Current Activities
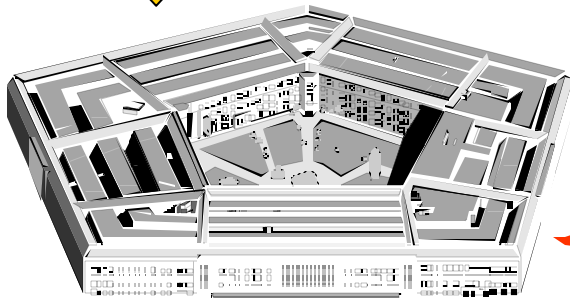- Avionics Planning and Execution (AVPLEX)
- Summary
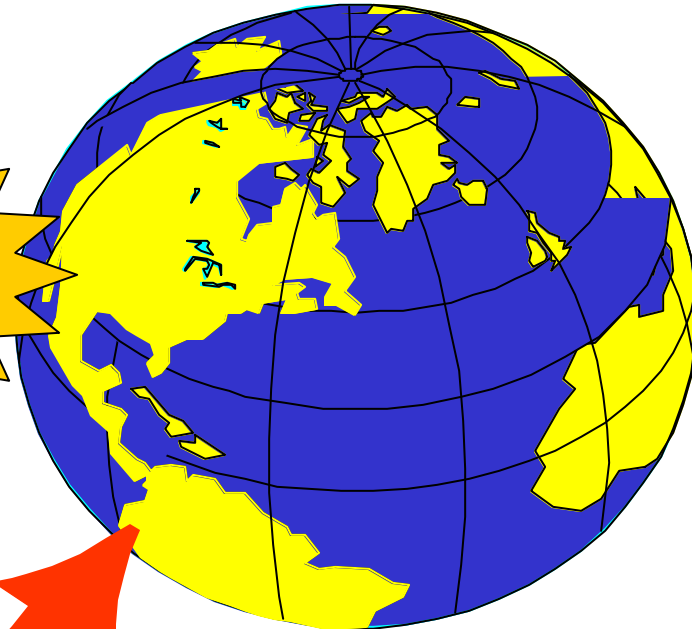
Why We Must Rely on the Commercial Marketplace...

Today

1950s

DOD no longer "drives" development. Instead, it must use what industry has developed for commercial applications.
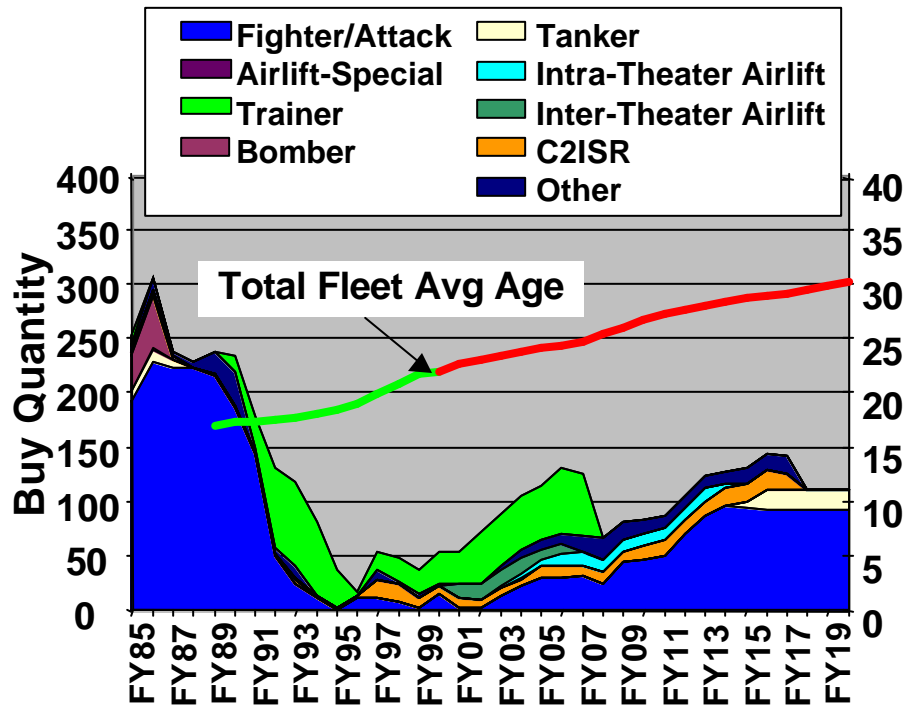
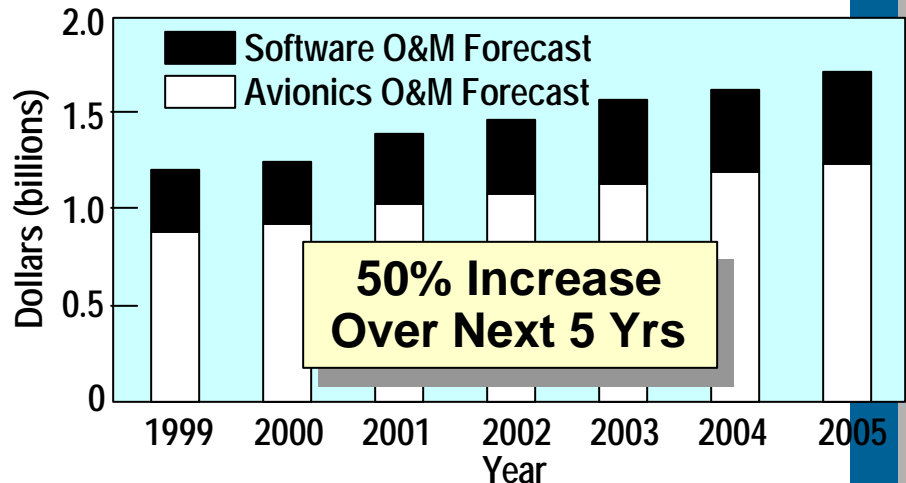**DEVELOPER & PRODUCER** ➡ **BUYER & INTEGRATOR**
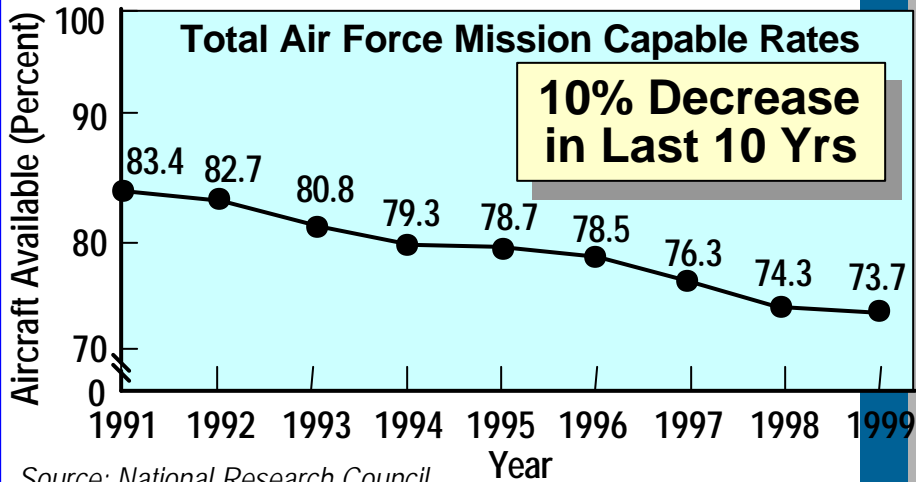
Military Trends
The Aging Aircraft Problem

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Open Systems
OS
Joint Task Force

Aircraft Age is Increasing…

Legend:
- Fighter/Attack
- Airlift-Special
- Trainer
- Bomber
- Tanker
- Intra-Theater Airlift
- Inter-Theater Airlift
- C2ISR
- Other

Total Fleet Avg Age

Y-axis (left): Buy Quantity — 0, 50, 100, 150, 200, 250, 300, 350, 400
Y-axis (right): 0, 5, 10, 15, 20, 25, 30, 35, 40
X-axis: FY85, FY87, FY89, FY91, FY93, FY95, FY97, FY99, FY01, FY03, FY05, FY07, FY09, FY11, FY13, FY15, FY17, FY19

Average Age of USAF Fleet is 22 Years!

O&M Costs are Increasing…

- Software O&M Forecast
- Avionics O&M Forecast

Y-axis: Dollars (billions) — 0, 0.5, 1.0, 1.5, 2.0
X-axis: Year — 1999, 2000, 2001, 2002, 2003, 2004, 2005

50% Increase Over Next 5 Yrs

Readiness is Declining…

Total Air Force Mission Capable Rates

10% Decrease in Last 10 Yrs

Y-axis: Aircraft Available (Percent) — 0, 70, 80, 90, 100

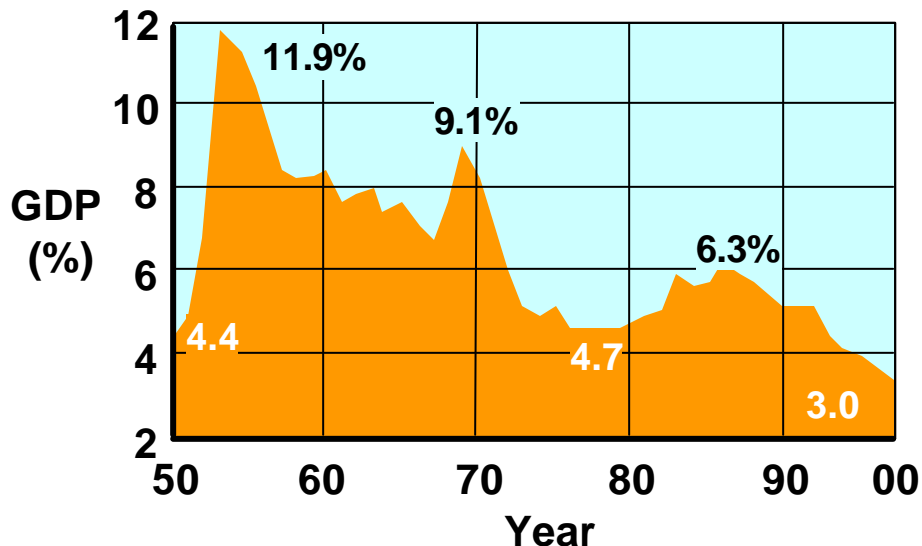| Year	Value
1991	83.4
1992	82.7
1993	80.8
1994	79.3
1995	78.7
1996	78.5
1997	76.3
1998	74.3
1999	73.7

X-axis: Year

Military Trends
Losing Market Leverage

Defense Spending is Declining…

Defense Outlays As a Share of Gross Domestic Product

GDP (%)

- 11.9%
- 9.1%
- 6.3%
- 4.4
- 4.7
- 3.0

Year: 50 60 70 80 90 00

DOD Budget (as % of GDP) is at the Lowest Level Since After WWII!

Source: Air Force Magazine, April 1997 (data from US Department of Defense)

Market Share is Decreasing…

1998 Total Worldwide Merchant Semiconductor Usage
Total $150 Billion
(Total Semiconductors 293,753)

- Computer 53%
- Consumer 17%
- Communications 15%
- Industrial 9%
- Auto 5%
- Military <1%

SOURCE: *ICE "Status 98"/TACTech*
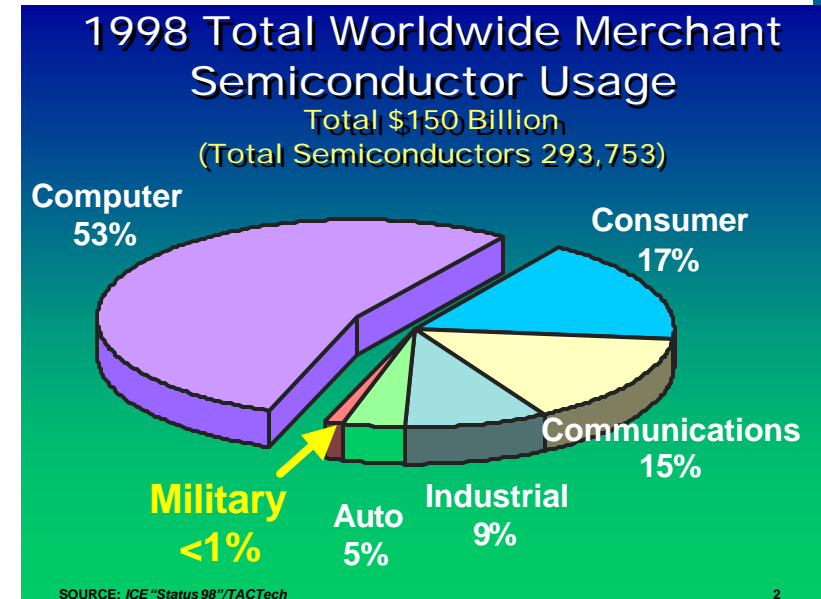
- **DOD Has Minimal Impact in the Electronics Industry**
- **Obsolescence is Market Driven**
  - It Won't Go Away
  - We Can't Change The Environment
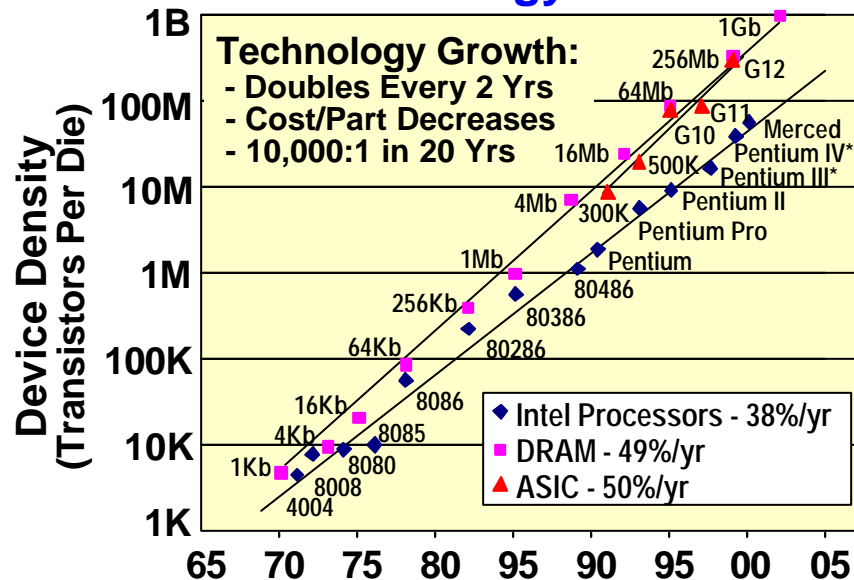- **DMS Results in Unaffordable NRE**
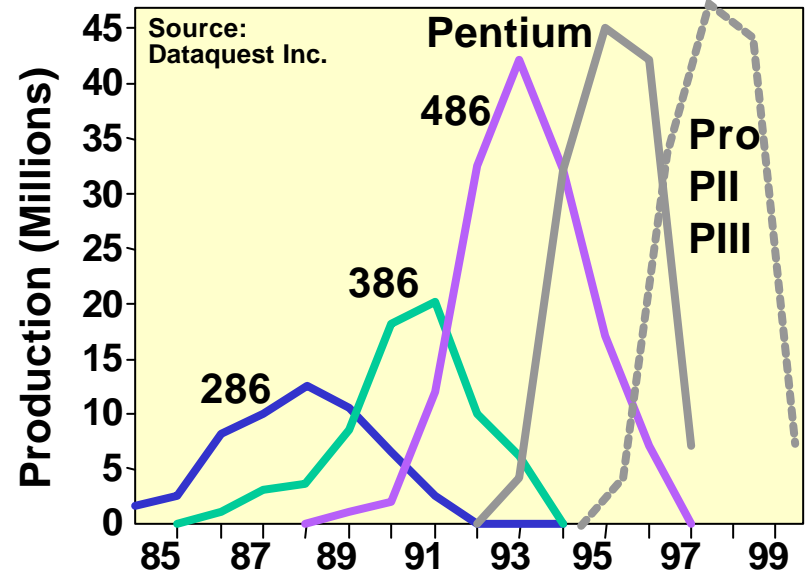
Commercial Technology Trends
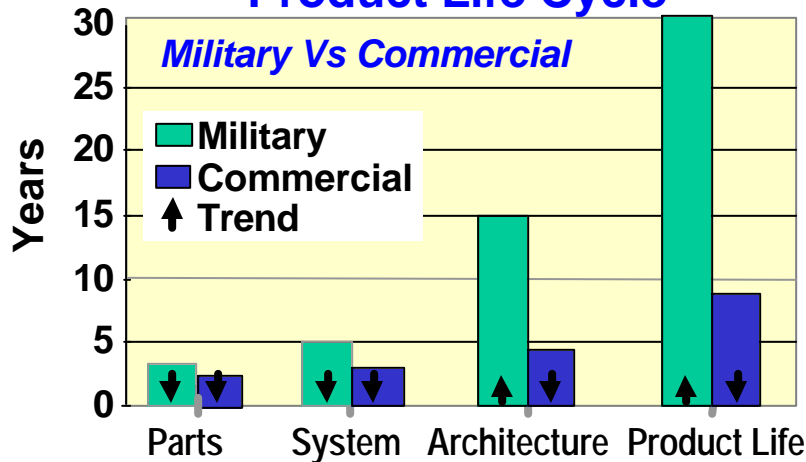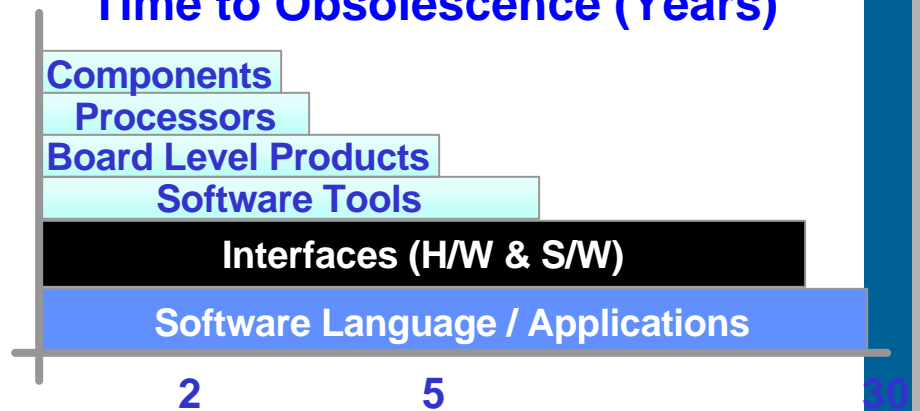## *Reduced Cost & Cycle Time*

Technology Evolution

Device Density (Transistors Per Die)

Technology Growth:
- Doubles Every 2 Yrs
- Cost/Part Decreases
- 10,000:1 in 20 Yrs

1B — 1Gb
256Mb — G12
64Mb
100M — G11
16Mb — G10 — Merced / Pentium IV* / Pentium III*
500K
10M — 4Mb / 300K — Pentium II / Pentium Pro
1Mb — Pentium
1M — 80486
256Kb — 80386
100K — 80286
64Kb — 8086
16Kb — 8085
10K — 4Kb — 8080
1Kb — 8008
4004

- ◆ Intel Processors - 38%/yr
- ■ DRAM - 49%/yr
- ▲ ASIC - 50%/yr

X-axis: 65 70 75 80 95 90 95 00 05

Shorter Product Lifetimes

Production (Millions)

Source: Dataquest Inc.

Pentium
486
386
286
Pro / PII / PIII

Y-axis: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45
X-axis: 85 87 89 91 93 95 97 99

Product Life Cycle

Years

Military Vs Commercial

- ▮ Military
- ▮ Commercial
- ↑ Trend

Y-axis: 0, 5, 10, 15, 20, 25, 30
X-axis: Parts System Architecture Product Life

Time to Obsolescence (Years)

Components
Processors
Board Level Products
Software Tools
Interfaces (H/W & S/W)
Software Language / Applications

2   5

Avionics Architecture Evolution

"Capturing the Benefits of Advanced Technology..."

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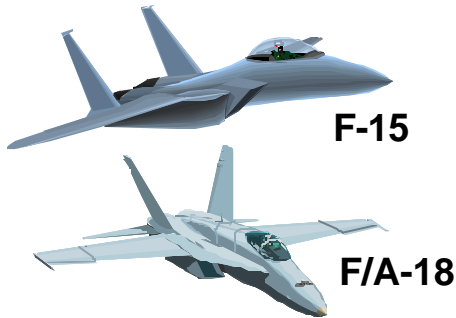
Federated Systems	Integrated Subsystems	Total Systems Integration
F-15	F-22	JSF
F/A-18		
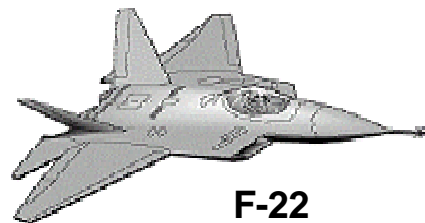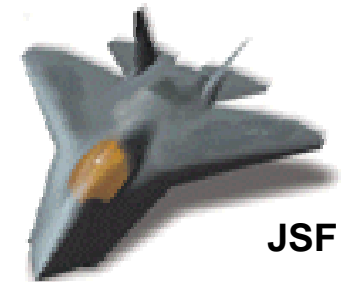
| 1970 1980	1990	2000 2010
• 12 Unique Processors	• 8 Unique Processors	• 1-2 Unique Processors
• 12 Software Languages (Ada High Order Language & Assembly Languages)	• 4 Software Languages (Ada High Order Language & Assembly Languages)	• 1 Common High Order Software Language & Object Oriented Design
• Unique Executive (OS) in Each Subsystem	• Initial Distributed Real-Time OS Developments	• Distributed OS with Standard Interfaces
• No Software Reuse	• Limited Software Reuse	• Significant Software Reuse
• >12 Unique Data Busses	• 8 Unique Data Networks	• 1 Common Data Network
• Box Level Redundancy	• Module Level Redundancy	• Highly Fault Tolerant

Open Systems
OS
Joint Task Force

System of Systems Example: JSF Architectural Hierarchy
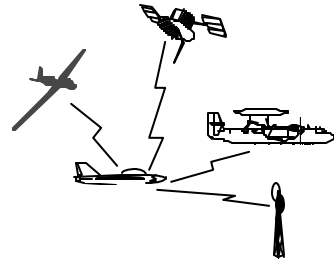
Level 1: Force Structure/ System of Systems

Level 2: Weapon System/ JSF

IRFS — ICP/SMS

IEOS — AUN

VMS

Stores Stations
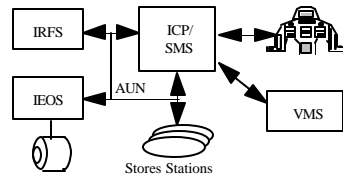
Level 3: Major Subsystem/ Avionics Suite
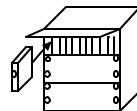
Level 4: Functional Area/ Integrated Core Processing

Level 5: Hardware/Software Building Block

Level 6: Hardware/Software Component

A Modular Open Systems Approach is...

"...a business and engineering strategy to choose specifications and standards

☞ adopted by industry standards bodies *or*
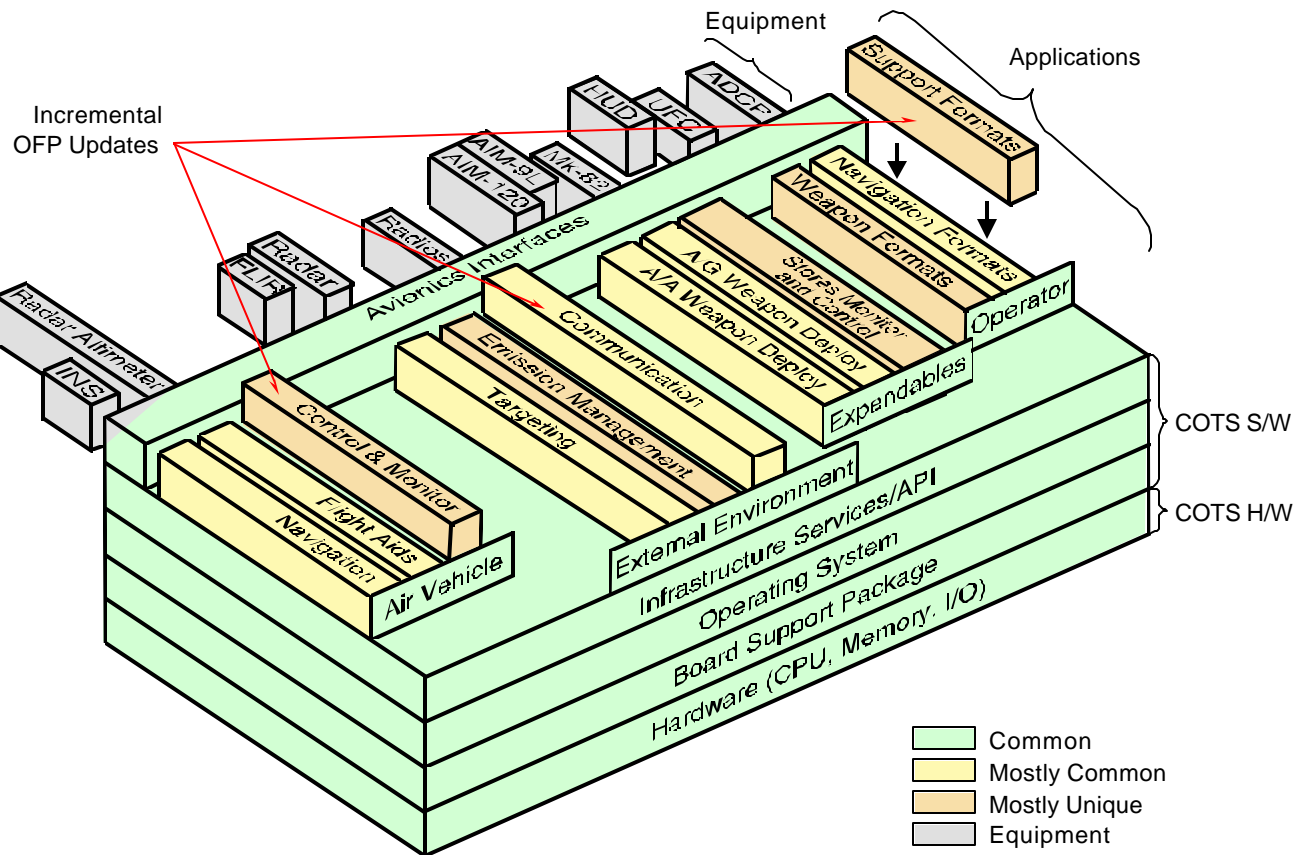
☞ *de facto* standards (set by the market place)

for selected systems interfaces (functional and physical), products, practices, and tools."

DOD 5000.2-R

23 March 1996

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Open Interfaces Isolate Hardware and Software Components

Incremental OFP Updates

Equipment

Applications

COTS S/W

COTS H/W

Legend:
- Common
- Mostly Common
- Mostly Unique
- Equipment

The Layered, Object-Oriented Design Provides O&S Savings by Facilitating Reusable Applications and Permitting Software Changes and Hardware Updates With Minimal Retesting

Open Systems Pioneer:
AV-8B Open Systems Core Avionics Requirements

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Two Components Impact ~ 75% of Routine Update Maintenance Cost

Stores Management Computer

Mission Computer

Operationally Suitable

Operationally Effective

Mission Needs and Operational Requirements Will Continue to Evolve Capabilities

2005

- SELF DIAGNOSTICS
- MSI
- VOICE INTERACTION
- IDECM
- ALR-67(VX)
- ALE-50(VX)
- LINK 16 CAPABILITY

Desired

- ANTI-SHIP MISSILE
- AIM-9X/HMD
- JSOW
- AMRAAM
- VMF DCS-2000
- TAV-8B ENGINE UPGRADE
- TARGETING POD/LASER TRACKER
- TAMMAC

Unfunded

2000

- TAMPS
- HQ/SINCGARS
- FLIGHT INCIDENT RECORDER
- JDAM
- MIL-STD-1760B
- DIGITAL FLAP CONTROLLER
- VIDEO FATIGUE DATA RECORDER
- CMWS/ASTE/ALE-47
- OSCAR
- ARC-210
- ATHS
- GPS

Night Attack / Radar

1996

Funded

AV-8Bs Must Remain Operationally Capable Through 2023

Open System Architecture for Legacy Aircraft (OSALA)

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Open Systems … Progress Towards Affordable Legacy Weapon Systems

Benefits ...

... Commercial Practices
- *"24-Month" Production F-16 Aircraft*
- *$10M Savings on Current Contracts*
- *$10M Savings on Future Contracts*

… Capacity Improvements
- *50 fold Increase in Network Capacity*
- *20 fold Increase in Processor Speed*

… O&S Reductions
- *10% Savings in Operations & Support*

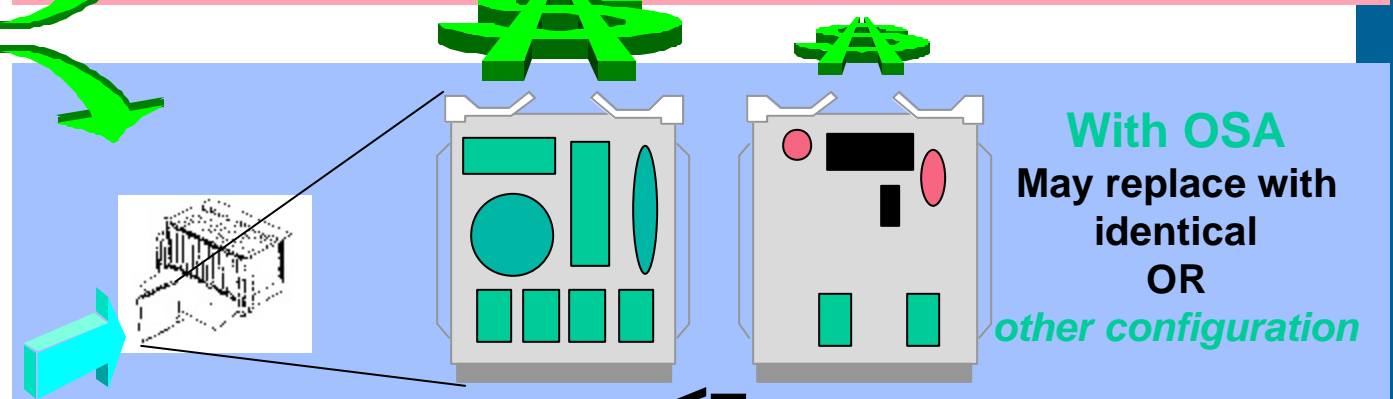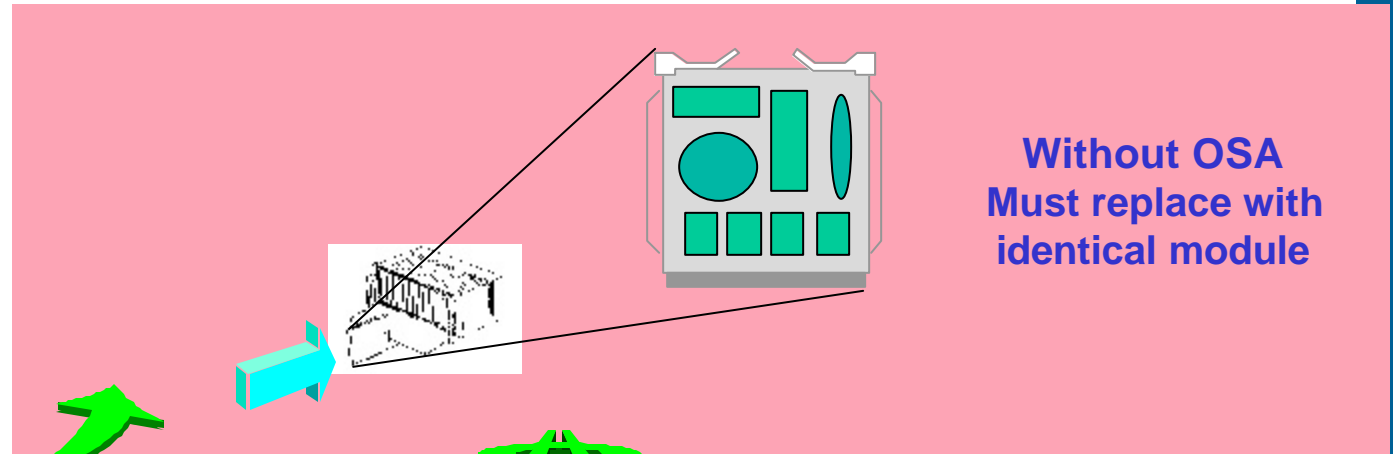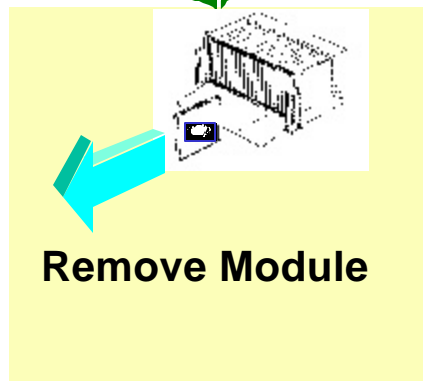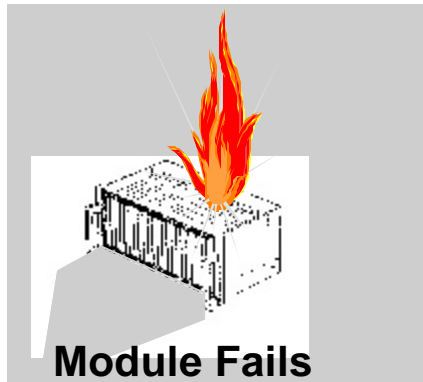### Open Interface Standards Are Now in Production Plans *(F-16 Block 60, UAE F-16s)*

✔ **Open High Speed Network**
  ⇨ *Commercial Protocol To Replace 1553B*
✔ **Commercial Processors**
  ⇨ *Color Displays in VME Chassis*
✔ **Common Modular Avionics**

Logistics Support Considerations:
Module Replacement or Upgrade?

Module Fails

Remove Module

**Without OSA
Must replace with
identical module**

With OSA
**May replace with
identical
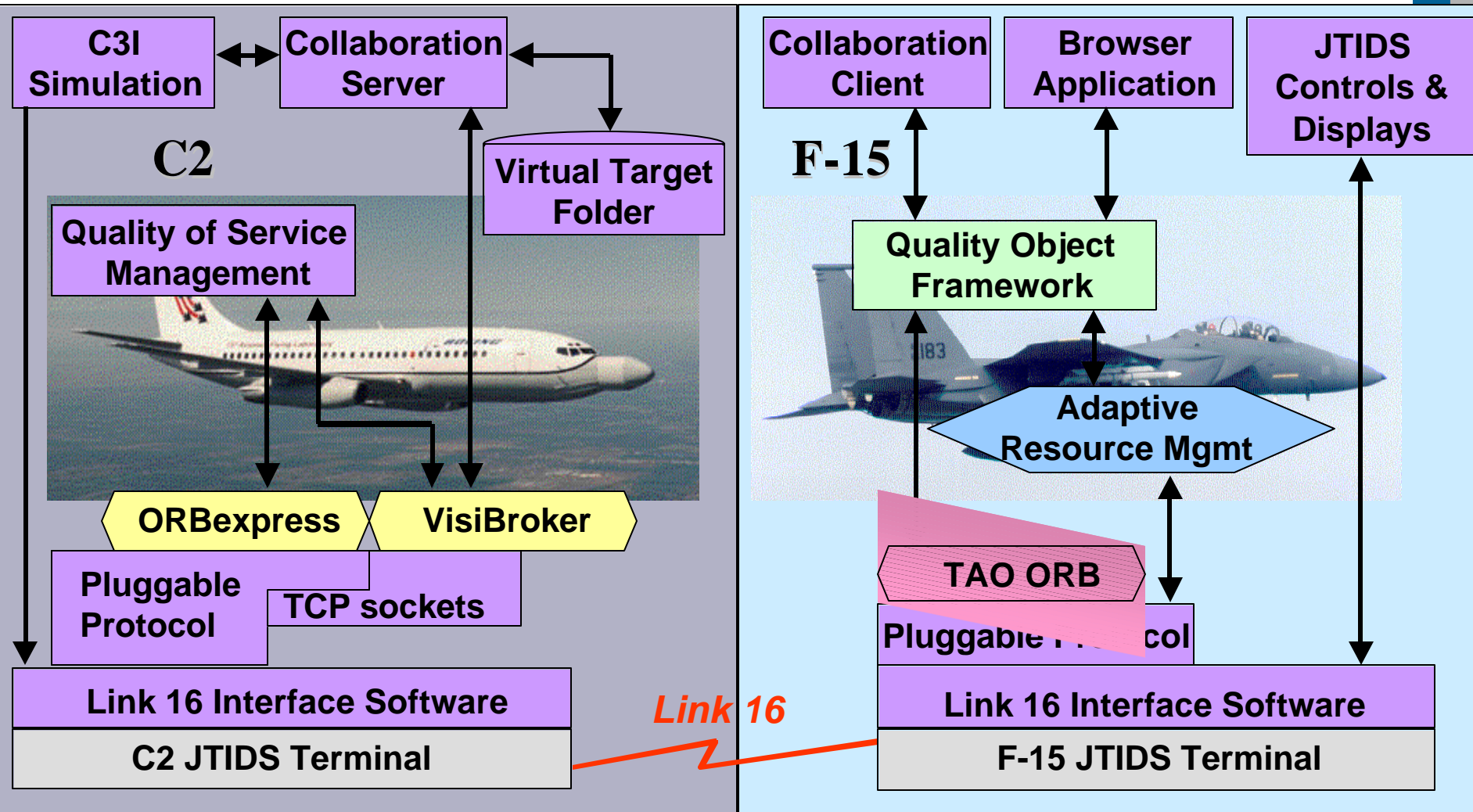OR
*other configuration***

<=

- **Module interface rigorously controlled**
  - » New interface must be backward compatible
- **Numerous operational configurations possible**
  - » **Not all possible configurations explicitly tested**

Weapon System Open Architecture (WSOA):
Collaborative Time Critical Target Prosecution Demo

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C3I Simulation ⟷ **Collaboration Server** → **Virtual Target Folder**

C2

Quality of Service Management

ORBexpress **VisiBroker**

Pluggable Protocol **TCP sockets**

Link 16 Interface Software

C2 JTIDS Terminal

Collaboration Client **Browser Application** **JTIDS Controls & Displays**

F-15

Quality Object Framework

Adaptive Resource Mgmt

TAO ORB

Pluggable Protocol

Link 16 Interface Software

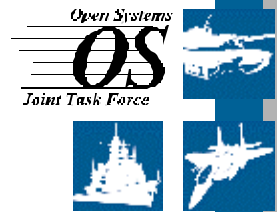**F-15 JTIDS Terminal**

Link 16

Other MOSA Activities

- **Acquisition Program Support to various programs and initiatives, e.g., AF Viable Combat Avionics, Navy's Total Ship Open Systems Architecture (TOSA), Army's WSTAWG**

- **MOSA Industry Steering Group hosted by the National Center for Advanced Technologies**

- **The Open Group Real-Time and Embedded Systems Forum**

- Uniqueness of Avionics recognized throughout AF
  - Common Avionics in ASC/SM
    - Eagle Look Report
    - Original Aging Avionics Tasking
  - CSAF Tasking for Affordable Avionics
  - QAPR Results
  - NCAT Affordable Avionics Initiative
  - Viable Combat Avionics
  - National Research Council Aging Avionics Report
- Avionics presents a different problem set and has a different goal than other elements of the aging aircraft
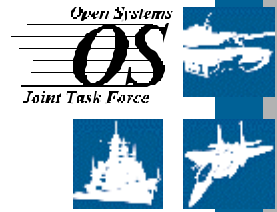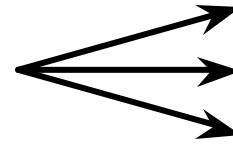
Requirements Analysis

- Formalized in User Documents
  - Mission Need Statement (MNS)
  - Operational Requirements Document (ORD)
- Key Considerations
  - Flexibility/Growth (Long Term Outlook)
  - Mission Changes and External Influences, e.g.,
    National Airspace Requirements
  - Performance in Lieu of Military Specifications
  - Open Systems
- User Involvement Must be Continuous

Systems Engineering

   Emphasizing

            Migration Strategy
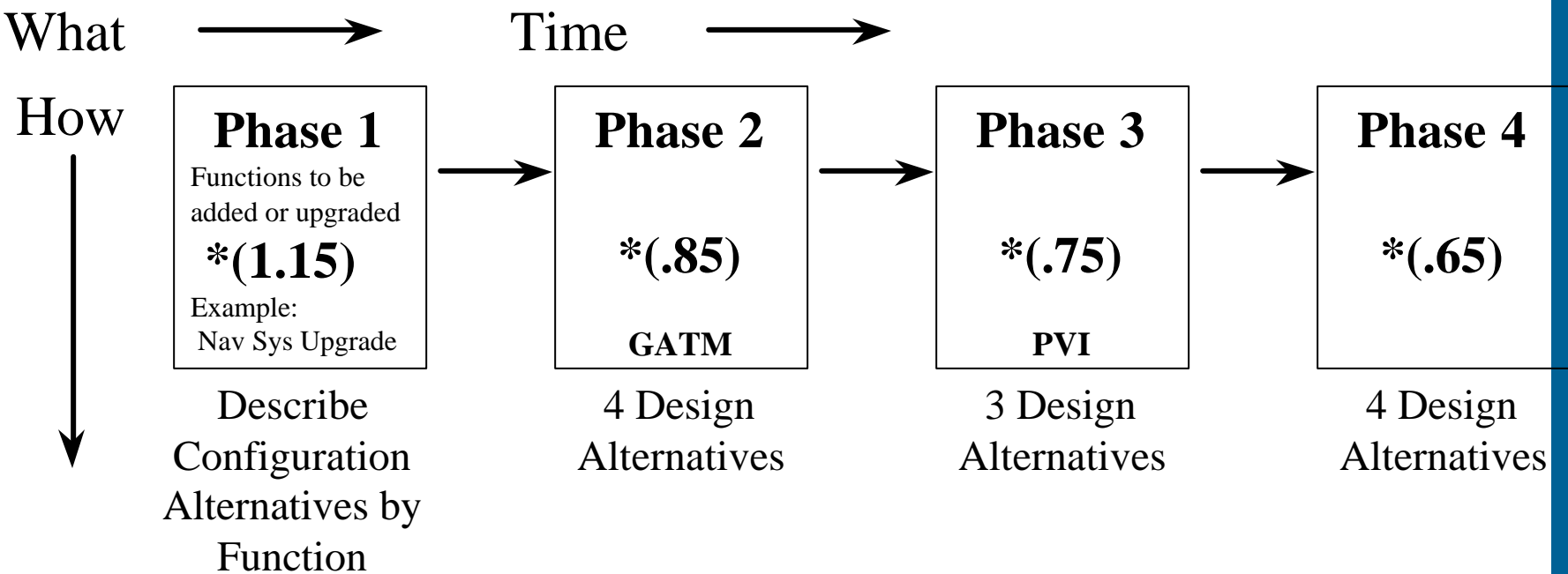   Life Cycle Cost
            Open Systems

- Requirements

- Migration Strategy

- Architecture Alternatives Development

- Life Cycle Cost Estimates

- Analysis of Alternatives

- Modification Program Approval

- Solicitations and Source Selection

Migration Strategy

A Plan for Managing Avionics Upgrades

What ———▶ Time ———▶

How

Phase 1 Functions to be added or upgraded ***(1.15)** Example: Nav Sys Upgrade	**Phase 2** ***(.85)** **GATM**	**Phase 3** ***(.75)** **PVI**	**Phase 4** ***(.65)**
Describe Configuration Alternatives by Function	4 Design Alternatives	3 Design Alternatives	4 Design Alternatives

*First system may cost more to set stage for later cheaper, faster modifications.

Why is Avionics Unique?
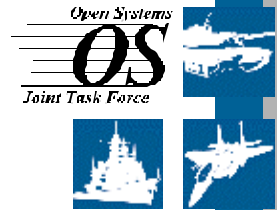
- Avionics upgrade goal is to add new capability
  - New capability for changing threats or PVI
  - National or international airspace mandates
- Goal of airframe or other aging aircraft systems is maintaining or extending service life
- Pace of technology change in avionics is order of magnitude greater that airframe or other systems
- Greater variance in avionics depending on design age

Needs a tailored approach because of uniqueness

Other Considerations
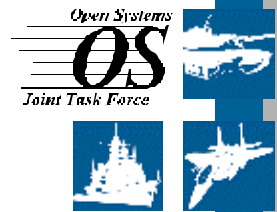
- Acquisition managers must acquire avionics from a different perspective:

  - Tell the offerors to address change in a roadmap context

  - Make ease of change a key element of a best value evaluation of offers

  - Select based on ease of change and long term ownership costs.

- Integration into legacy system can represent significant challenges: i.e. Software and DMS/OP issues

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- Performance Based Requirements

  – Provides greater design trade latitude to industry

  – Adjustment to this business approach has been difficult for both government and industry

    - Industry familiar with Military Specs & Stds

    - Government understanding of how to specify performance

- Performance requirements need to be specified based on mission requirements and supportability

 – Needs to be an element of program definition

Conclusions that Impact Organization

- VCA is a business issue as well as a technology approach. Challenge is integration of commercial items into new environment

- Performance based acquisition means new ways to specify and evaluate requirements

- Avionics upgrades must be evolutionary, incremental and to be cost effective must be based on a migration strategy

- Avionics support methods are changing and will rely more on industry for aircraft system and component repair

- Process orientation change can confuse users & industry
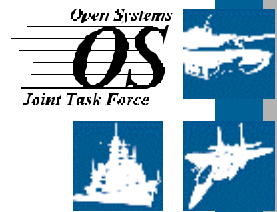
- Platform Up rather than Common Down
  - Focus has been and needs to remain focus on platform migration strategies or Integrated Change Roadmaps
  - "Embryonic"process recognized by NRC and recommended to continue
  - Core Avionics team making progress and needs to remain as a unit to continue the synergy
- Cross-cutters need to be based on the Integrated Change Roadmaps (ICRs)
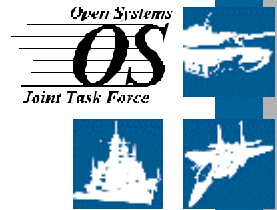
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The Bad News is…..
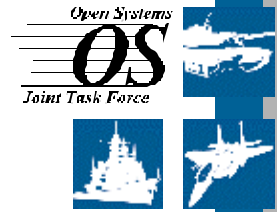
- The pace of process change is glacial while the technology change continues to accelerate.

- Roles and relationships between industry and the government are still evolving and not fully understood

- Integration remains the frequently misunderstood element

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- Apparent consensus on the need for incremental, integrated approach to Avionics planning and execution

- Definitional battles have slowed saving energy for the real issues

- Policies and processes being put in place to execute the needed changes

- Organizations to help Program Offices apply the new concepts

Evolutionary Acquisition is facilitated by MOSA